International Journal of Computer and Information Technology (ISSN: 2279 – 0764)
Volume 04 – Issue 04, July 2015

Simulation-based Performance Evaluation of Selected Routing Protocols in Mobile Ad hoc Networks

Goitom Abrehaley
School of Electrical and Computer Engineering
Ethiopian Institute of Technology, Mekelle
Mekelle, Tigray, Ethiopia

Maribel Tolentino* and Gebremedhn Mehari
School of Electrical and Computer Engineering
Ethiopian Institute of Technology, Mekelle
Mekelle, Tigray, Ethiopia
*Email: maribel.tolentino6712 [AT] gmail.com

Abstract - **The dynamic nature of mobile ad hoc networks makes them ideal candidates for a number of applications. These networks are quick to deploy and require minimal configuration thus making them suitable for emergencies such as natural disasters and Military environments etc. MANETs are also used to extend service coverage in cost effective ways. As technology advances in the development of devices such as Wi-Fi capable laptops, mobile phones and other portable devices, MANETs are increasingly becoming popular. After years of research, MANET protocols do not have a complete formed Internet standard. There is only been an identification of experimental Request For Comments (RFCs) since 2003 [4]. Aggressive research in this area has continued since then with prominent studies on Destination Sequenced Distance vector, Dynamic Source Routing and Ad hoc on demand Distance Vector and Temporary Ordered Routing protocol. The simulations were performed using NS2 and the post analyses were done using mat-lab. The traffic sources are CBR (constant bit-rate). The source-destination pairs are spread randomly over the network. The simulation study consisted of three routing protocols AODV, DSR and DSDV, analyzing their behavior with respect to routing overhead, throughput, average end-to-end delay; packet delivery ratio, Normalized Routing Load, jitter and packet loss and their results are shown in graphical forms. This paper provides insight into the performance evaluation of the most common mobile ad-hoc routing protocols.**

Index Terms – Performance Evaluation, Routing Protocols, MANETS, AODV, DSDV, DSR.

I. INTRODUCTION

In the past few years, we have seen a rapid expansion in the field of mobile computing due to the proliferation of inexpensive, widely available wireless devices. However, current devices, applications and protocols are solely focused on cellular or wireless local area networks (WLANs), not taking into account the great potential offered by mobile ad hoc networking. A mobile ad hoc network is an autonomous collection of mobile devices (laptops, smart phones, sensors, etc.) that communicate with each other over wireless links and cooperate in a distributed manner in order to provide the necessary network functionality in the absence of a fixed infrastructure. This type of network, operating as a stand-alone network or with one or multiple points of attachment to cellular networks or the Internet, paves the way for numerous new and exciting applications. The performance of nodes in ad hoc networks is critical, since the amount of available power for excessive calculation and radio transmission are constrained. In addition, the available bandwidth and radio frequencies may be heavily restricted and may vary rapidly. Finally, as the amount of available memory and CPU power is typically small, the implementation of strong protection for ad hoc networks is non-trivial.

After years of research, MANET protocols do not have a complete formed Internet standard. There is only been an identification of experimental Request For Comments (RFCs) since 2003 [4]. At this stage, there is an indication that questions are unanswered concerning either implementation or deployment of the protocols but the proposed algorithms are identified as a trial technology and there is a high chance that they will develop into a standard [4]. Aggressive research in this area has continued since then with prominent studies on Destination Sequenced Distance vector (DSDV), Dynamic Source Routing (DSR) and Ad hoc on demand Distance Vector (AODV) and Temporary Ordered Routing protocol (TORA).
This project provides insight into the performance evaluation of the most common mobile ad-hoc routing protocols.

A. Problem Statement

There are several IP routing protocols, with competing features, developed for wireless ad hoc networks. These protocols have varying qualities for different wireless routing aspects. It is due to this reason that choice of a correct routing protocol is critical. This paper have tried to address three main questions. The first is 'Which routing protocol provides a better performance in Mobile Ad hoc Networks?' This question addresses the overall performance of each routing protocol investigated in this project. The second question addresses the factors that influence the performance of these routing protocols. Finally yet important, the paper tried to address the major differences in the routing protocols under study. In trying to answer these questions, the paper introduces a model of MANET scenarios with varying traffic loads and mobility scenarios and evaluated the performance of AODV, DSR and DSDV with respect to routing overhead, throughput, average end-to-end delay; packet delivery ratio, Normalized Routing Load, jitter and packet loss. The premise in this study is that no single routing protocol among AODV, DSR and DSDV is clearly superior to the others in terms of overall network performance. One protocol may be superior in terms of average end-to-end delay while another may perform better in terms of routing overhead and throughput. The performance of the routing protocol will greatly depend on various factors such as network load and mobility effects.

II. Literature Survey

Sravya et. al [15] compares the performance of routing protocols for mobile ad hoc networks i.e. Ad hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Destination Sequence Distance Vector (DSDV) over a MAC Layer protocol IEEE 802.11. As per their findings the differences in the protocol mechanics lead to significant performance differentials for these protocols. Always the network protocols were simulated as a function of mobility, but not as a function of network density. In their paper the performance of AODV, DSDV and DSR is evaluated with respect to performance metrics like Packet Delivery Fraction (PDF), Average end-to-end delay, Normalized Routing Load (NRL), and Dropped packets by varying network size. These simulations are carried out using the NS-2 which is the main network simulator. Mukesh Kumar Garg et. al. [16] In the paper an attempt has been made to evaluate and compare the performance of two most commonly used on-demand-driven routing protocols named as AODV & DSR. The performance of both these routing protocols has been simulated using QualNet 5.0 Simulator. From their findings they have concluded that neither of the protocol is better in all situations. For some parameters one outperforms the other and vice-versa as reported in the paper. Sengar Abhishek et. al. [20] compares the performance AODV (Ad-hoc on demand distance vector) and DSDV (Destination sequence distance vector) routing protocols' performance on the basis of different criteria for performance. Here, an attempt has been made to evaluate the performance of two well known routing protocols AODV, DSDV by using three performance metrics such as packet delivery ratio, throughput and Routing overheads. The Performance evaluation has been done by using simulation tool NS2 (Network Simulator) which is the main simulator. Parul Sharma et. al.[24] In this three routing protocols AODV (Ad- Hoc On-Demand Distance Vector), DSDV (Destination Sequenced Dis-tance-Vector) and DSR (Dynamic Source Routing Protocol) are compared. The performance of these routing protocols is analyzed in terms of their Packet Delivery Fraction, Average End-to-End Delay. Payal et.al[25] This paper does the comparative investigations on the performance of routing protocols Dynamic Source Routing (DSR), Ad-hoc On demand distance vector (AODV) and Destination-Sequenced Distance-Vector (DSDV) for wireless ad-hoc networks in a simulated environment against varying parameters considering UDP as transport protocol and CBR as traffic generator. In this paper, they have studied the effects of varying node mobility rate, scalability and maximum speed on the performance of ad-hoc network routing protocols.

III. Routing Protocols in Manets

An ad hoc routing protocol [1] is a standard for controlling node decisions when routing packets traverse a MANET between devices. A node in the network, or one trying to join, does not know about the topology of the network. It discovers the topology by announcing its presence and listening to broadcasts from other nodes (neighbors) in the network. The process of route discovery is performed differently depending on the routing protocol implemented in a network.

There are several routing protocols designed for wireless ad hoc networks. Routing protocols are classified either as reactive or proactive .There are also some ad hoc routing protocols with a combination of both reactive and proactive characteristics. These are referred to as hybrid.

A. Proactive Routing Protocols

Proactive (table-driven) routing protocols are similar to the connectionless schemes of traditional datagram networks. These protocols employ classical routing strategies such as distance-vector (e.g. DSDV) or link-state (e.g. OLSR) routing and any changes in the link connections are updated periodically throughout the network. Proactive protocols maintain routing information about the available paths in the network even if these paths are not currently used. The main disadvantage of these protocols is the maintenance of unused paths may occupy an important part of the available bandwidth if the network topology changes frequently. However, proactive protocols may not always be suitable for highly mobile networks such as MANETs.

Destination sequenced distance vector routing (DSDV)

Destination sequenced distance vector routing (DSDV)[4] is adapted from the conventional Routing Information Protocol (RIP) to ad hoc networks routing. It adds a new attribute, sequence number, to each route table entry of the conventional RIP. Using the newly added sequence number, the mobile nodes can distinguish stale route information from the new and thus prevent the formation of routing loops.

Packet Routing and Routing Table Management [8] In DSDV, each mobile node of an ad hoc network maintains a routing table, which lists all available destinations, the metric and next hop to each destination and a sequence number generated by the destination node. Using such routing table stored in each mobile node, the packets are transmitted between the nodes of an ad hoc network. Each node of the ad hoc network updates the routing table with advertisement periodically or when significant new information is available to maintain the consistency of the routing table with the dynamically changing topology of the ad hoc network. Periodically or immediately when network topology changes are detected, each mobile node advertises routing information using broadcasting or multicasting a routing table update packet. The update packet starts out with a metric of one to direct connected nodes. This indicates that each receiving neighbor is one metric (hop) away from the node. It is different from that of the conventional routing algorithms.

After receiving the update packet, the neighbors update their routing table with incrementing the metric by one and retransmit the update packet to the corresponding neighbors of each of them. The process will be repeated until all the nodes in the ad hoc network have received a copy of the update packet with a corresponding metric. The update data is also kept for a while to wait for the arrival of the best route for each particular destination node in each node before updating its routing table and retransmitting the update packet. If a node receives multiple update packets for a same destination during the waiting time period, the routes with more recent sequence numbers are always preferred as the basis for packet forwarding decisions, but the routing information is not necessarily advertised immediately, if only the sequence numbers have been changed. If the update packets have the same sequence number with the same node, the update packet with the smallest metric will be used and the existing route will be discarded or stored as a less preferable route. In this case, the update packet will be propagated with the sequence number to all mobile nodes in the ad hoc network. The advertisements of routes that are about to change may be delayed until the best routes have been found.

Delaying the advertisement of possibly unstable route can damp the fluctuations of the routing table and reduce the number of rebroadcasts of possible route entries that arrive with the same sequence number. The elements in the routing table of each mobile node change dynamically to keep consistency with dynamically changing topology of an ad hoc network. To reach this consistency, the routing information advertisement must be frequent or quick enough to ensure that each mobile node can almost always locate all the other mobile nodes in the dynamic ad hoc network. Upon the updated routing information, each node has to relay data packet to other nodes upon request in the dynamically created ad hoc network.

B. Reactive Routing Protocols

Reactive (on-demand) routing protocols **(**e.g. AODV, DSR, TORA) employ a lazy approach whereby mobile nodes only discover routes to destinations on-demand. These protocols maintain only the routes that are currently in use, thus reducing the burden on the network when only a few of all available routes is in use at any time.

Reactive protocols often consume less bandwidth than proactive protocols, but the delay in determining a route can be substantially large. In reactive protocols, since routes are only maintained while in use, it is typically required to perform a route discovery process before packets can be exchanged between nodes. Therefore, this leads to a delay for the first packet to be transmitted. Another disadvantage is that, although route maintenance is limited to the routes currently in use, it may still generate a significant amount of network traffic when the network topology changes frequently. Finally, packets transmitted to the destination are likely to be lost if the route to the destination changes.

Dynamic Source Routing protocol (DSR)

The Dynamic Source Routing protocol (DSR) [2] is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. Using DSR, the network is completely self-organizing and self-configuring, requiring no existing network infrastructure or administration. Network nodes cooperate to forward packets for each other to allow communication over multiple "hops" between nodes not directly within wireless transmission range of one another. As nodes in the network move about or join or leave the network, and as wireless transmission conditions such as sources of interference change, all routing is automatically determined and maintained by the DSR routing protocol.
Since the number or sequence of intermediate hops needed to reach any destination may change at any time, the resulting network topology may be quite rich and rapidly changing. In designing DSR, we sought to create a routing protocol that had very low overhead yet been able to react very quickly to changes in the network. The DSR protocol provides highly reactive service in order to help ensure successful delivery of data packets in spite of node movement or other changes in network conditions.

Adhoc On-Demand Distance Vector Routing Protocol

The Ad hoc On-Demand Distance Vector (AODV) RFC 3561 algorithm enables dynamic, self-starting, multi hop routing between participating mobile nodes wishing to establish and maintain an ad hoc network. AODV allows mobile nodes to obtain routes quickly for new destinations, and does not require nodes to maintain routes to destinations that are not in active communication. AODV allows mobile nodes to respond to link breakages and changes in network topology in a timely manner. The operation of AODV is loop-free, and by avoiding the Bellman-Ford "counting to infinity" problem offers quick convergence when the ad hoc network topology changes (typically, when a node moves in the network). When links break, AODV causes the affected set of nodes to be notified so that they are able to invalidate the routes using the lost link. One distinguishing feature of AODV is its use of a destination sequence number for each route entry. The destination sequence number is created by the destination to be included along with any route information it sends to requesting nodes. Using destination sequence numbers ensures loop freedom and is simple to program. Given the choice between two routes to a destination, a requesting node is required to select the one with the greatest sequence number.

IV. Performance Metric and Simulation Environment

The simulations were performed using NS2 and the post analyses were done using mat-lab. The traffic sources are CBR (constant bit-rate). The source-destination pairs are spread randomly over the network. The mobility model uses 'TwoRayGround' in a rectangular filed of 500m x 500m with varying number of nodes. During the simulation, each node starts its journey from a random spot to a random chosen destination. Once the destination is reached, the node takes a rest period of time in second and another random destination is chosen after that pause time. This process repeats throughout the simulation, causing continuous changes in the topology of the underlying network.

A. The simulation Software(NS2)

NS2 [13] is an open-source event-driven simulator designed specifically for research in computer communication networks. Since its inception in 1989, NS2 has continuously gained tremendous interest from industry, academia, and government. Having been under constant investigation and enhancement for years, NS2 now contains modules for numerous network components such as routing, transport layer protocol, application, etc. To investigate network performance, researchers can simply use an easy-to-use scripting language to configure a network, and observe results generated by NS2. Undoubtedly, NS2 has become the most widely used open source network simulator, and one of the most widely used network simulators.

a. Running NS2 Simulation

1. NS2 Program Invocation

After the installation and/or recompilation an executable file ns is created in the NS2 home directory.
NS2 can be invoked by executing the following statement from the shell environment:

>>ns [<file>] [<args>]

where <file> and <args> are optional input argument. If no argument is given, the command will bring up an NS2 environment, where NS2 waits to interpret commands from the standard input (i.e., keyboard) line-by-line. If the first input argument <file> is given, NS2 will interpreted the input scripting <file> (i.e., a so-called Tcl simulation script) according to the Tcl syntax. Finally, the input arguments <args>, each separated by a white space, are fed to the Tcl file <file>. From within the file <file>, the input argument is stored in the built-in variable argv.

2. Main NS2 Simulation Steps

The following show the three key step guideline in defining a simulation scenario in a NS2:

Step 1: Simulation Design

The first step in simulating a network is to design the simulation. In this step, the users should determine the simulation purposes, network configuration and assumptions, the performance measures, and the type of expected results.

Step 2: Configuring and Running Simulation

This step implements the design in the first step. It consists of two phases:

- *Network configuration phase:* In this phase network components (e.g., node, TCP and UDP) are created and configured according to the simulation design. Also, the events such as data transfer are scheduled to start at a certain time.
- *Simulation Phase*: This phase starts the simulation which was configured in the Network Configuration Phase. It maintains the simulation clock and executes events chronologically. This phase usually runs until the simulation clock reached a threshold value specified in the Network Configuration Phase.

In most cases, it is convenient to define a simulation scenario in a Tcl scripting file (e.g., <file>) and feed the file as an input argument of an NS2 invocation (e.g., executing "ns <file>").

Step 3: Post Simulation Processing

The main tasks in this step include verifying the integrity of the program and evaluating the performance of the simulated network. While the first task is referred to as *debugging*, the second one is achieved by properly collecting and compiling simulation results.

B. Wireless networking in NS-2

a. Mobile Node

Wireless networking in NS-2[14] is defined by having a mobile node. A Mobile Node thus is the basic Node object with added functionalities of a wireless networks. Mobile nodes have the following functionalities:

- Ability to move within a given topology
- Ability to receive and transmit signals to and from a wireless channel etc.

A major difference between a node of wired network and mobile node is that a Mobile Node is not connected by means of Links to other nodes or mobile nodes. Moreover, routing in mobile networks especially in Ad-hoc networks is distributed and there is no centralized entity (as router in wired network). Therefore a mobile node acts as a router and as a node at the same time.

b. Node movement

The mobile node is designed to move in a three dimensional topology. However the third dimension (Z) is not used. That is, the mobile node is assumed to move always on a flat terrain with Z always equal to 0. Thus, the mobile node has X, Y, Z(=0) coordinates that is continually adjusted as the node moves.

There are two mechanisms to induce the movement in mobile nodes. In the first method, starting position of the node and its future destinations may be set explicitly. These directives are normally included in a separate movement scenario file. The starting position and future destinations for a mobile node may be set by using the following APIs:

$node set X_ \<x1\>
$node set Y_ \<y1\>
$node set Z_ \<z1\>
$ns at $time $node setdest \<x2\> \<y2\> \<speed\>

At $time sec, the node would start moving from its initial position of (x1,y1) towards a destination (x2,y2) at the defined speed. In this method the node-movement-updates are triggered whenever the position of the node at a given time is required to be known. This may be triggered by a query from a neighboring node seeking to know the distance between them, or the setdest directive described above that changes the direction and speed of the node. An example of a movement scenario file using the above APIs can be found in ***tcl/mobility/scene/scen-500x500-50-40-25-0.*** Here, 500x500 defines the length and width of the topology with 50 nodes moving at a maximum speed of 25m/s with an average pause time of 40s. These node movement files may be generated using CMU's scenario generator which is found under ***indep-utils/cmu-scen-gen/setdest.***

The second method employs random movement of the node. The primitive to be used is: $mobile node start which starts the mobile node with a random position and has routine updates to change the direction and speed of the node. The destination and speed values are generated in a random fashion. The mobile node movement is implemented in C++. Irrespective of the methods used to generate the node movement, the topography for mobile nodes needs to be defined. It should be defined before creating the mobile nodes. Normally, flat topology is created by specifying the length and width of the topography using the following primitive:

set topo [new Topography]
$topo load_flatgrid $opt(x) $opt(y)

where opt(x) and opt(y) are the boundaries used in simulation. The movement of the node is determined by setting an area and mobility scenarios.

V. Performance Evaluation and Design

Different performance metrics are used in the evaluation of routing protocols. They represent different characteristics of the overall network performance. This part presents the design parameters of the system and the various metrics considered in the performance evaluation of the routing protocols.

A. Performance Metric

A number of quantitative metrics can be used for evaluating the performance of a routing protocol.

1. PACKET DELIVERY FRACTION (PDF)

This is the ratio of total number of packets successfully received by the destination nodes to the number of packets sent by the source nodes throughout the simulation.

PDF=Number of Packets received/ Number of Packets Sent

This estimate gives me an idea of how successful the protocol is in delivering packets. A high value of Packet Delivery Fraction indicates that most of the packets are being delivered to the higher layers and is a good indicator of the protocol performance. The simulation results are shown in the following section in the form of line graphs. Graphs show comparison between the three protocols by varying different numbers of sources on the basis of the above-mentioned metrics as a function of pause time and number of traffic sources.

2. AVERAGE END-TO-END DELAY

This is the average time involved in delivery of data packets from the source node to the destination node. To compute the average end-to-end delay, add every delay for each successful data packet delivery and divide that sum by the number of successfully received data packets.

Ave End to End Delay = Σ (Time Received - Time Sent) / Total Data Packets Received

3. NORMALIZED ROUTING LOAD (NRL)

The normalized routing load is defined as the fraction of all routing control packets sent by all nodes over the number of received data packets at the destination nodes. This metric discloses how efficient the routing protocol is. The bigger this fraction is the less efficient the protocol.

Normalized Routing Load = Total Routing Packets Sent / Total Data Packets Received

4. THROUGHPUT

It is the measure of how fast a node can actually sent the data through a network. So throughput is the average rate of successful message delivery over a communication channel.

5. ROUTING OVERHEAD

It is the ratio of the total number of routing packets sent and the total number of packets sent.

6. PACKET LOSS (PL)

Packet loss occurs when one or more packets being transmitted across the network fail to arrive at the destination. It is defined as the number of packets dropped by the routers during transmission.

Packet Loss = Total Data Packets Sent – Total Data Packets Received

Packet Loss (%age) = (Total Packets Dropped X 100)/Total Data Packets Sent

7. ENERGY

This study has added energy breakdown in each state in the traces to support detailed energy analysis. In addition to the total energy, now users will be able to see the energy consumption in different states at a given time. Following is an example from a trace file on energy.

[energy 979.917000 ei 20.074 es 0.000 et 0.003 er 0.006]

The meaning of each item is as follows:

energy: total remaining energy
ei: energy consumption in IDLE state
es: energy consumption in SLEEP state
et: energy consumed in transmitting packets
er: energy consumed in receiving packets

8. AVERAGE JITTER

Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes.

VI. RESULTS AND DISCUSSIONS

A. Simulation Methods, Results and Analysis

The goal of this paper is to examine and quantify the effects of various factors and their interactions on the overall performance of ad hoc networks. Each run of the simulator accepts as input a *scenario file and Traffic file* that describes the exact motion of each node using Random Waypoint mobility model and the exact sequence of packets originated by each node together with exact time at which change in packet or motion origination occurs.

The metrics used for evaluating MANET performance are calculated by using AWK commands base.

B. Performance evaluation as a function Network Load Analysis

In this analysis the number of nodes varied from 20 to 120 with an increment of 20 nodes and the pause time is also set 40sec and 80 sec. whereas network size and simulation duration are fixed at 500X500 sq. m. and 120s respectively.

Table 1. Simulation Parameters for Network Load

No	Parameter Name	Value
1	Routing Protocols	DSDV,AODV and DSR
2	Mobility Model (Propagation)	TwoRayGround
3	Antenna	OmniAntenna
4	Simulation Time	120 sec
5	Pause time	40sec/80sec
6	Channel	WirelessChannel
7	Link layer	LL
8	Simulation Area	500X500
9	Traffic type	CBR
10	Packet size	512 bytes
11	MAC	Mac/802_11
12	Band width	8kbps
13	Simulator	Ns2 .35 and matlab
14	Performance Metrics	Average Throughput [kbps],Packet delivery Fraction, Energy Consumption of Protocol(Joules)

The performance plots i.e. Average Throughput [kbps] vs. number of nodes, Packet Delivery Fraction [%] vs. number of nodes and Energy Consumption of protocol vs. number of nodes is shown in Figures 1, 2 and 3 respectively. In terms of Average Throughput the DSR protocol has higher throughput in comparison with AODV and DSDV as shown in Figure 1. If the pause time of nodes is increased then the Average Throughput of AODV and DSR are very closer. Whereas the Average Throughput of DSDV is always low. From Figure 2 it is observed that the DSR outperforms the AODV and DSDV whereas it is very closer with AODV in terms of PDF by increasing the nodes. From these figures we observe that the PDF of DSDV drops sharply in some point of the simulation time.

In terms Energy Consumption of protocol as seen in Figure 3 the DSDV protocol consumes very large amount of energy compared to AODV and DSR protocols.

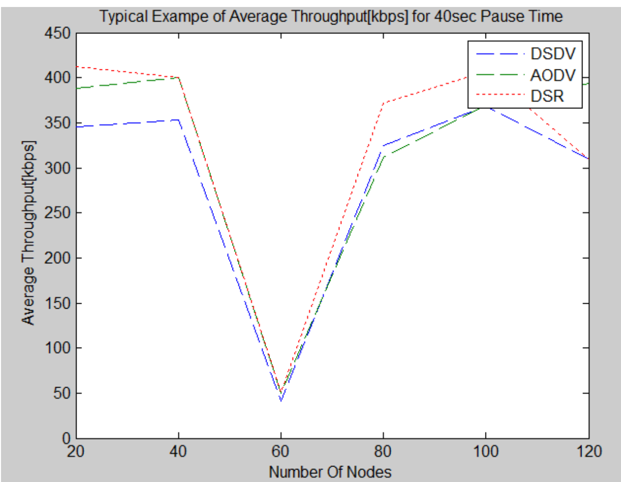

Figure 1. Average Throughput vs. number of nodes for 40sec pause time.

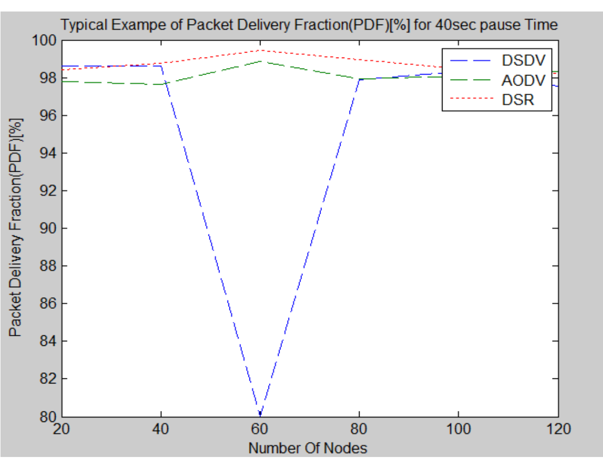

Figure 2. Packet Delivery Fraction vs. Num of nodes for 40s pause time

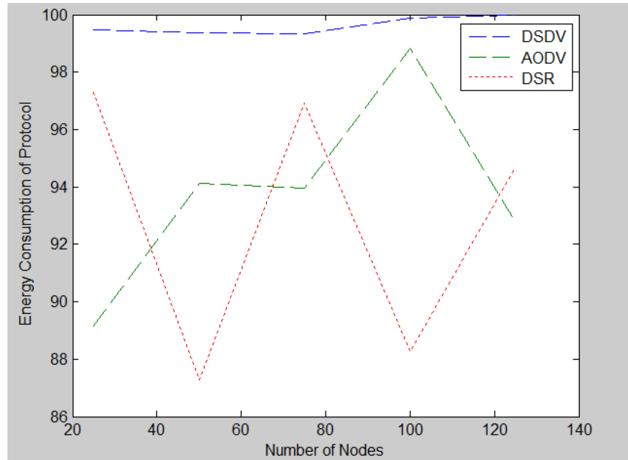

Figure 3. Energy Consumption of protocol vs. number of nodes for 40 sec and 80sec pause time

C. Performance evaluation as a function Mobility Analysis

In this analysis, it is assumed that each node has different mobility rate and direction. It is considered “TwoRayGround Mobility” model of NS2 simulator to generate different mobility scenario. The maximum speed which is an important factor is fixed at around 25 m/s.

Table 2. Simulation Parameters for Mobility

No	Parameter Name	Value
1	Routing Protocols	DSDV,AODV and DSR
2	Mobility Model (Propagation)	TwoRayGround
3	Antenna	OmniAntenna
4	Simulation Time	120 sec
5	Number of Nodes	5/25/50
6	Channel	WirelessChannel
7	Link layer	LL
8	Simulation Area	500X500
9	Traffic type	CBR
10	Packet size	512 bytes
11	MAC	Mac/802_11
12	Band width	8kbps
13	Simulator	Ns2 .35 and matlab
14	Performance Metrics	Average Throughput [kbps],Packet delivery Fraction, Routing over head, Normalized routing load, average end to end delay, packet loss and jitter

The performances like Average Throughput [kbps],Packet delivery Fraction, Routing over head, Normalized routing load, average end to end delay, packet loss and jitter are measured by varying the pause time which is reported in Figure 4 to Figure 10.

In terms of Average Throughput DSR has the highest throughput and DSDV has the lowest throughput when the number of nodes is small. When the number of nodes were increased the Average Throughput of DSR and AODV is very close to each other. The Average Throughput of all routing protocols gradually decreases with increase in the pause time as shown in Figure 4.

The average packet delivery ratio has an irregular trend. It is observed that AODV and DSR outperformed DSDV for any node density whereas the packet deliver fraction of AODV and SR is very close with each other as shown in Figure 5. It is also observed that the routing overhead of DSR is high whereas the routing overhead of DSDV and AODV is zero for any range of nodes.

N.B. the same conclusion holds for Normalized Routing Load too (see figure 6).

In terms of average end to end delay DSR has the highest average end to end delay and DSDV has the lowest average end to end delay for very small number of nodes. But for large number of nodes AODV has the highest average end to end delay where DSDV and DSR has very close average end to end delay (see Figure 7).

From Figure 8, it can be observed that the number of dropped data packets is higher for DSDV compared to AODV and DSR. The number of dropped data packets for DSR and AODV has irregular pattern for small number of nodes, but when the number of nodes were increased the number of dropped data packets is closer to each other.

In terms of Occurrence of jitter during end to end delay AODV is higher than DSR till 40sec pause time, but after 40sec DSR is higher than AODV where DSDV has the lowest Occurrence of jitter during end to end delay for small number of nodes.

For large number of nodes DSDV has initially the highest Occurrence of jitter during end to end delay till 40sec pause time, but after 40sec pause time AODV has the highest Occurrence of jitter during end to end delay whereas DSDV and DSR has very closer Occurrence of jitter (see Figure 9).

N.B. similar conclusion holds for the Occurrence of jitter between the intermediate nodes too (see Figure 10).

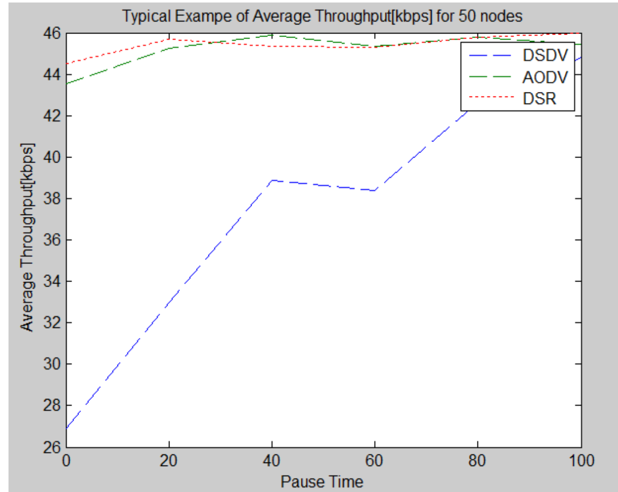

Figure 4. Average Throughput [kbps] vs. pause time (sec) for 50 nodes

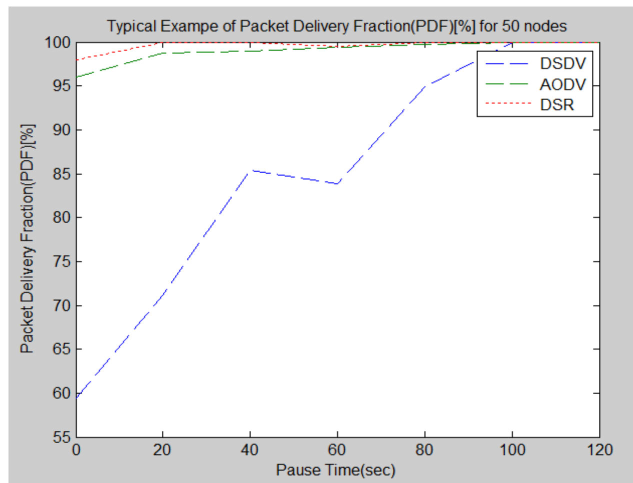

Figure 5. Packet Delivery Fraction vs. pause time (sec) for 50 nodes.

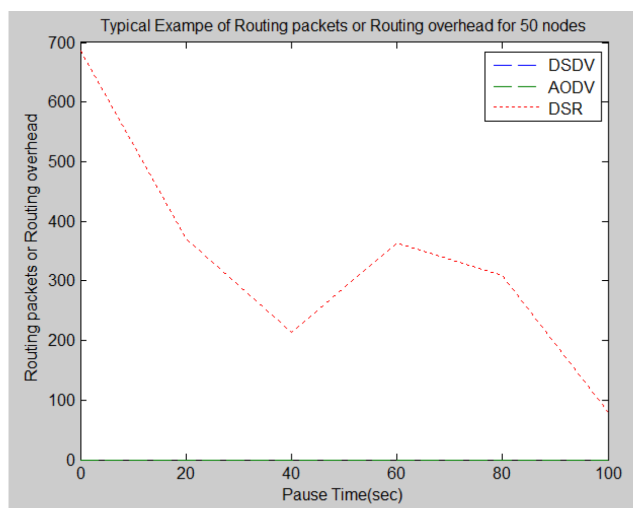

Figure 6. Routing packets/overhead vs. pause time for 50 nodes

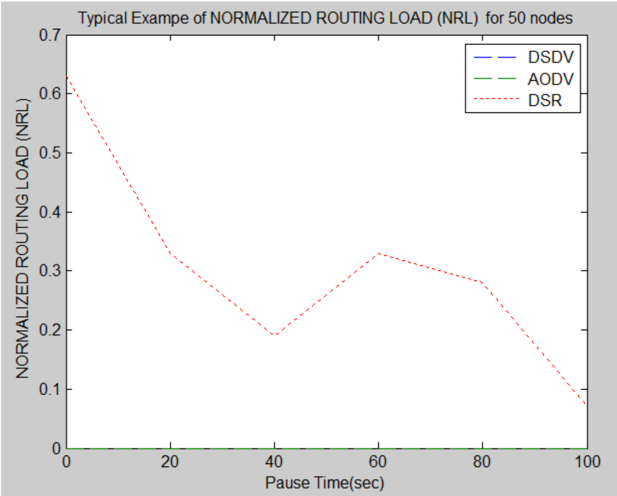

Figure 7. Normalized Routing Load vs. pause time (sec) for 50 nodes

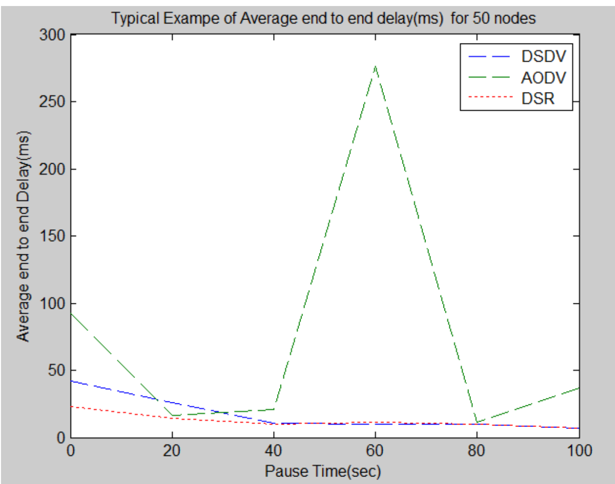

Figure 8. Average end to end delay vs. pause time (sec) for 50 nodes

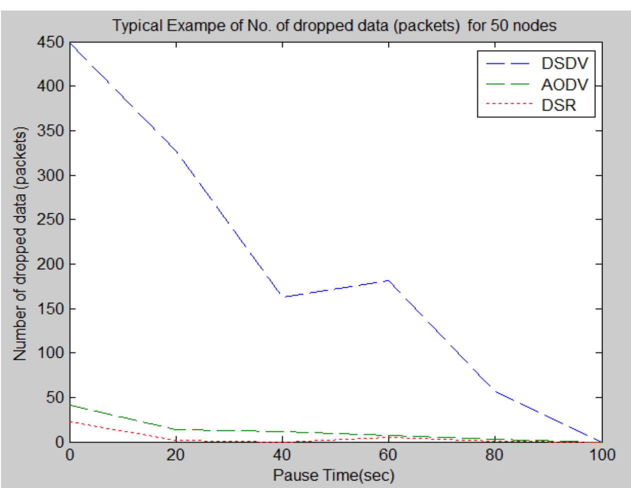

Figure 9. Number of Dropped Data vs. pause time (sec) for 50 nodes

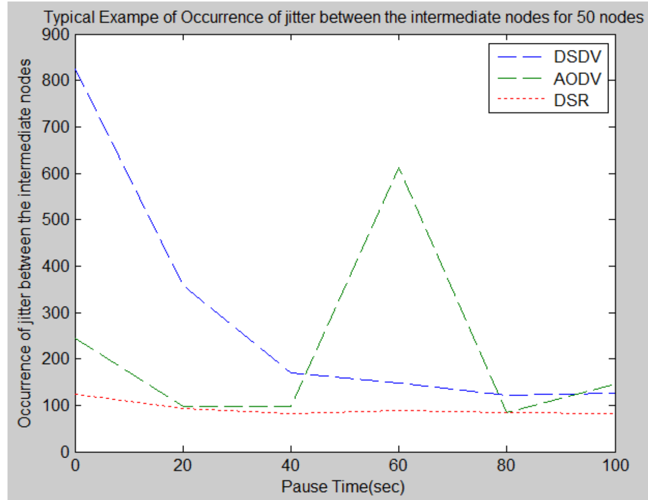

Figure 10. Occurrence of jitter between the intermediate nodes vs. pause time (sec) for 50 nodes

VI. Conclusion

This work mainly consists of two studies, one is analytical study and other is simulation study. From analytical study it is concluded that routing protocols in mobile ad-hoc networks play prominent role to develop better communication between mobile nodes. The selection of suitable protocol according to the network definitely increases the reliability of that network.

The simulation study consisted of three routing protocols AODV, DSR and DSDV, analyzing their behavior with respect to routing overhead, throughput, average end-to-end delay; packet delivery ratio, Normalized Routing Load, jitter and packet loss and their results are shown in graphical forms. The motive was to check the performance of these three routing protocols in MANET in the above mentioned parameters.

The conclusions of entire study from my experimental results are as follows:

Simulation results indicate that despite in most simulations reactive routing protocols DSR and AODV performed significantly better than proactive routing protocol DSDV, DSR is less scalable with respect to network size because DSR introduces high overheads with the increase in network size. Simulations presented clearly show that there is a need for routing protocol specifically tuned to the characteristics of ad-hoc networks.

The next step for the future work would be to evaluate the performance of these protocols with respect to varying network area and it can be extended to various other protocols like TORA and also analyze performance of such protocols on the performance parameter like path optimality, delay overload and energy consumption, find the performance routing protocol after a malicious attack on the network and propose the secure scheme for the ad-hoc network etc.

REFERENCES

[1] Bained Nyirenda and Jason Mwanza, "*Performance Evaluation of Routing Protocols in Mobile Ad hoc Networks (MANETs)*".

[2] David B. Johnson, David A. Maltz and Yih-Chun Hu , *"The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks (DSR)"*, 16-Apr-2003.

[3] C. Perkins , E. Belding-Royer and S. Das ,"*Ad hoc On-Demand Distance Vector (AODV) Routing*"

[4] R. Misra and C.R. Mandal, "*Performance comparison of AODV/DSR on-demand routing protocols for ad hoc networks in constrained situation*" , ICPWC International Conference, IEEE, 2005, pp. 86 – 89

[5] http://nsnam.isi.edu/nsnam/index.php/ : Visited on Feb 21, 2014.

[6] S. Corson and J. Macker, "*Mobile Ad hoc Networking (MANET), Routing Protocol Performance Issues and Evaluation Considerations*".

[7] Guoyou He,*"Destination-Sequenced Distance Vector (DSDV) Protocol",* Networking Laboratory ,Helsinki University of Technology.

[8] Perkins Charles E., Bhagwat Pravin: "*Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers*", London England UK, SIGCOMM 94-8/94.

[9] J. B. Postel, editor. "*Transmission Control Protocol*". September 1981.

[10] IEEE Computer Society LAN MAN Standards Committee. "*Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications*", IEEE Std 802.11-1997. The Institute of Electrical and Electronics Engineers, New York, New York, 1997

[11] John Jubin and Janet D. Tornow,"*The DARPA Packet Radio Network Protocols",* Proceedings of the IEEE, 75(1):21--32, January 1987.

[12] V. Park and S. Corson, "*Temporally-Ordered Routing Algorithm (TORA) Version 1 Functional Specification".*

[13] Teerawat Issariyakul and Ekram Hossain, "*Introduction to Network Simulator NS2*", e-ISBN: 978-0-387-71760-9

[14] Etsegenet Awash ,"*Evaluation of Various Routing Protocols for Mobile Ad-hoc Networks*".

[15] Sravya .V, Nagaraju. A and Pavani. K, *"Performance Evaluation of IEEE 802.11 with DSDV, DSR, AODV Routing Protocols in MANETs*" ,International Journal of Engineering and Science ISBN: 2319-6483, ISSN: 2278-4721, Vol. 2, Issue 1,(January 2013), PP 33-39

[16] Mukesh Kumar Garg and Dr. Ela Kumar, *"The Performance Evaluation of AODV & DSR (On-Demand-Driven) Routing Protocols using QualNet 5.0 Simulator*", International Journal of Computer Science and Network , 2013

[17] Nehal Jadeja and Roma Patel*, "Performance Evaluation of AODV, DSDV and DSR Routing Protocols Using NS-2 Simulator",* International Journal of Engineering Research and Applications, Vol. 3, Issue 2, March -April 2013, pp.1825-1830.

[18] Ankur Lal, Dr.Sipi Dubey and Mr.Bharat Pesswani,*"Reliability of MANET through the Performance Evaluation of AODV, DSDV, DSR",* International Journal of Advanced Research in Computer Science and Software Engineering, Volume 2, Issue 5, May 2012.

[19] S. D. Khatawkar , K. K. Pandyaji, R. M. Patil , V. M. Sali and U. L. Kulkarni*, "Performance Comparison of DSDV, AODV, DSR, Routing protocols for MANETs",* International Conference on Computer Networks and Communication Systems, IPCSIT vol.35(2012)

[20] Er.Abhishek Sengar and Er.Sandeep Shrivastav, "*Performance Evaluation of AODV and DSDV Routing Protocols for Ad-hoc Networks*", Global Journal of Computer Science and Technology Network, Web & Security, Volume 12 Issue 16 Version 1.0, Year 2012

[21] ER. Saurabh mittal and PINKI, "*Performance Evaluation of AODV, DSR, DSDV AND TORA Routing Protocols",* International Journal of Multidisciplinary Research, Vol.2 Issue 2, February 2012, ISSN 2231 5780.

[22] Samyak Shah, Amit Khandre, Mahesh Shirole and Girish Bhole, *"Performance Evaluation of Ad Hoc Routing Protocols Using NS2 Simulation"*

[23] Priyanka Jangirm and Saurabh Mishra," *Protocols in Mobile Ad-hoc Networks Performance Comparison of DSDV, AODV AND DSR for Mobile Ad-hoc Network by Varying Network Size*", Conference on Advances in Communication and Control Systems 2013 (CAC2S 2013).

[24] Parul Sharma, Arvid Kalia and Jawahar Thakur, "*Performance Analysis of AODV, DSR and DSDV Routing Protocols in Mobile Ad-hoc network (MANET)*", Journal of Information Systems and Communication, ISSN: 0976-8742 & E-ISSN: 0976-8750, Volume 3, Issue 1, 2012, pp.-322-326

[25] Payal, Sudesh and Kr. Jakhar , "*CBR Traffic Based Performance Investigations of DSDV, DSR and AODV Routing Protocols for MANET Using NS2*", International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-3, Issue-4, September 2013